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PHYSICAL CHEMISTRY: RETROSPECT AND PROSPECT[1]

By Dr. HUGH S. TAYLOR

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THE Kansas City meeting of the American Chemical Society happens to divide into two halves the expected professional life of one of the members devoting his major activities to the pursuit of knowledge in the field of physical chemistry. It is this fact which has prompted a retrospect of the subject over a period of twenty-two years and some thoughts on the prospects of the science in the subsequent two decades.

To gain a perspective of physical chemistry in those apparently far-off days prior to 1914 resort may be made to the most advanced text-book of physical chemistry of that time, the text-book by Nernst, which, fortunately for our purposes, was issued in a seventh edition in 1913. Whilst one turns its pages, the omissions, in terms of our science of to-day, come readily to mind. In respect to the gaseous state of matter it is evident that kinetic theory was by them in an advanced state of development. Interest was beginning to center in the theoretical treatment of heat capacity vital to the problem of equilibria. The liquid state of aggregation has not shared in the rapid changes of these decades, although recently there has been a change of view-point whereby the analogies between the liquid and solid states is stressed in contrast with the former association of gaseous and liquid states. The study of the solid state was, in 1914, in the initial stages of an activity which has continued to the present. The limitations of the Dulong and Petit Law were known, and heat capacity data over wide ranges of temperature had led to a theoretical

[1] An address to the ninety-first meeting of the American Chemical Society at Kansas City, April 13, 1936.

treatment of the specific heats of crystals. But, at that time, crystallography was still empirical, ready to yield to the scientific approach, based on x-ray analysis. How great have been these contributions in two decades to inorganic, organic, stereo-chemistry and metallurgy from the x-ray studies!

The fundamentals of chemical equilibrium had been developed prior to 1914, though much of two decades has been devoted to enlarging the details. Of especial note in this field are the theoretical developments which permit an approach to the problems of equilibrium on the basis of statistical mechanics and the data of spectroscopy. It is now almost true to say that the theoretical calculation of gaseous equilibria, in both homogeneous and heterogeneous systems, is, in many cases, superior to the experimental determination. The range of capacity in this matter is continuously extending.

The application of classical thermodynamics, the first and second laws, to chemical equilibria in gases and solutions has been systematized, largely through the pioneering work of Lewis and his pupils, which made Gibbs practical to the working chemist. Others build continuously on their solid foundations. Nernst's Heat Theorem extended the rôle of thermodynamics in equilibria. Its utility and its limitations have been explored, and it has provided a rational approach to the problem of equilibria in organic reactions with consequent wide applicability in modern industrial chemistry.

Electrolytic equilibria had received, by 1914, an intensive development, but the problem of strong and weak electrolytes was not rationalized until the Debye-Hückel Theory laid the foundations for a resolution of the problem. Salt effects of uni- and polyvalent ions obtained thereby a lucid interpretation. The intensive study, with exact technique, of cell reactions has contributed greatly to these developments and we owe to such measurements much of our new knowledge of thermodynamic concentrations in ionized media. In passing, let us thank electrochemistry for providing the first separation of pure isotopes of the element hydrogen.

It is difficult for the student of physical chemistry to-day to visualize the situation in 1914 in respect to chemical kinetics. In that field alone are to be found some of the most spectacular developments in theory and in major industrial applications. In the field of homogeneous gas reactions, in rapid succession, came the kinetic theory treatment of bimolecular gas reactions and the first modern concept of the old active molecule of the Arrhenius treatment. Next came unimolecular decomposition processes, the basic reactions of the modern petroleum cracking industry, chain reactions, fundamental in the oxidation of gaseous fuels, in processes of chlorination and quite recently in technically important processes of polymerization to yield synthetic rubbers, resins and gasoline. With the concept of reaction chains came a full realization of the scope of inhibitor action and possible technical application in anti-knock materials, and inhibitors of deterioration in fats, oils, rubber, essential oils, pharmaceuticals and foods. The resolution of complex reactions into the simpler components, involving atom-molecule reactions, paved the way not only for the induction of reactions at lower temperatures but also for an entirely new theoretical treatment of the problem of reaction speed and activation. This recent development, which already, in the simpler processes, permits a quantitative theoretical calculation of the absolute rates of chemical reaction, has opened up to the theoretical chemist of the coming generation a rich field to cultivate. I plead with those in charge of large departments of chemistry or chemical research, here and abroad, to include in their personnel at least one who can bring to the problems of chemistry the rich assistance of statistical and quantum mechanical theory.

In the field of heterogeneous reaction kinetics, of contact catalysis, the development of fundamental principles has been equally pronounced. The progress prior to 1914 which produced such important technical developments as contact sulfuric acid, hydrogenation of oils, catalytic hydrogen manufacture and, lastly, ammonia synthesis can not be minimized. But the developments of the science of surface action, in the researches of Langumir, in the demonstration of surface heterogeneity, in the elucidation of the mechanism of poisons and promoter action, have given to the subject a scientific technique which is in large measure responsible for the rapidity of technical development, as illustrated in the synthesis of alcohols and esters, catalytic hydrogenations and dehydrogenations. To the future in this field let us return a few moments later.

In the second edition of the "Treatise on Physical Chemistry" published in 1931 there is a solid block of some 375 pages, representing more than one fifth of the total work, which is practically entirely absent in the physical chemistry of Nernst in 1913. These sections treat of the applications of quantum theory to atomic and molecular structure and the science of photochemistry in its newer aspects based upon the quantum concept. It is in this portion of the subject that the most fundamental advances have been made, with consequences in thermochemistry, equilibria, energetics of molecular assemblies to which brief allusion has already been made. Developments in this field have made possible conclusions concerning the initial stages in excitation of molecules by radiation of vari-

ous types and a more penetrating approach to the problems of reaction mechanism. The later developments in quantum mechanics have indicated the methods of theoretical approach to the chemist's problems of valency, stereochemical properties, homo-polar and ionic types of binding as well as to the phenomenon of activation energy, the controlling factor in rates of reaction. The new mechanics also has taught us the phenomenon of spin isomerization involving spins of the electrons and nuclei of symmetrical molecules, with important practical consequences in the case of hydrogen and conclusions that can not be avoided in the computation of equilibrium conditions involving other molecules. The discovery of Raman spectra, the more intensive study of infra-red and ultra-violet absorption spectra, dipole moments, x-ray and electron diffraction have provided us with further possibilities in the eludication of molecular structure. The spectral studies as well as the development of the mass spectrograph have enormously expanded our concept of isotopes which first came to our consciousness through the discoveries in the chemistry of radioactive substances in the early days of 1914. The closing years of these two decades of change have brought the isolation of two isotopes of hydrogen with all the consequences in chemical kinetics, in nuclear transmutations and biological research which resulted. Other isotope separations are within reach. Nuclear transmutations, whether with deuterium, as conspicuously developed by Lawrence, Cockcroft and Walton or with neutrons as discovered by the Curie-Joliots and developed by Fermi, have provided the chemist of the next two decades with radioactive isotopes with which to multiply the spectacular achievements attained with deuterium. A beginning in this field has already been made and the years immediately ahead will be significant.

If the gains in the field of surface chemistry have been substantial in the decades just concluded, the gains yet to be achieved are no less attractive. Excellent as are the results of studies of surface action already completed we still are far from an ideal which everywhere around us compels our attention. We can achieve a certain chastening of spirit if we contemplate the perfection of chemical action that is attained in vital processes. The enzymatic processes of digestion, synthesis sensitized by chlorophyll, the multi-functional activities possessed by the hormones indicate a level of reaction technique far above that of the most delicate of our reaction processes *in vitro*. We shall need to learn much more in these coming years of the adaptation of the catalyst, whether in a surface or a large molecule, to the particular process to be achieved. We need, to borrow once more the analogy from Fischer, a key more exactly fashioned to the lock to be opened than is usual in our present contact catalysts. We need for this purpose a more penetrating knowledge of complex organic structures. We need also to know more concerning the coupling of two or more chemical processes, the energy available from the one to supply the energetic needs of the other. In this field, it is probable indeed that the organic chemist will need the most energetic assistance of the physical chemist. The wonderful recent achievements in the organic chemistry of biologically important compounds such as the vitamins and the hormones must not be allowed to obscure the fact that these are problems intrinsically much simpler than those which involve carbohydrates, glucosides and proteins, largely because of the greater molecular complexity of the latter. We do not yet see how the synthetic and analytic studies so successful with the simpler biological molecules can be transferred to the more complex molecules. In the meantime the physical chemist can be of assistance, helping towards a solution of the problem by kinetic, colloidal and stereo-analytical studies. The physico-chemical technique which is even now being developed for the analysis of problems in the synthetic polymer field is so much gained in the approach to the problem of complex biological structures.

The last decade has seen the development of our knowledge and control of reactions involving atoms and molecule fragments. We are beginning to learn something of the individualities of the free radicals whose lifetime is measured in small fractions of a second. We are learning how to manipulate these fragments of high reactivity into patterns more suited to our needs. Any one who knows the differences, in fuel value, for example, between a straight chain octane and iso-octane, standard of anti-knock rating, must recognize the importance of such controlled rearrangements. We can no longer be content to take our molecules "as we find them," as Kipling once said of the British soldier, but rather, in the words of the older poet, we must be ready "to shatter them to bits and then remould them nearer to the heart's desire."

It is not, however, the rôle of the physical chemist to sketch out the many consequences in applied science which will certainly follow from the more intensive development of the theoretical aspects of the subject. To others the glory and the plaudits that come for obvious and spectacular benefits of science to human society. Ours the humbler and yet more satisfying task—to reveal the origins of things—to order our knowledge even more scientifically, ever less empirically. For it is of our faith that the less empirical the science becomes, the more assured do we become in its application. The years ahead will reveal the men to carry on the glorious traditions of Dalton and Faraday, of Helmholz and Gibbs, of van't Hoff and

Arrhenius, of Ostwald and Nernst, of Einstein, Debye and Langmuir, the men who, by their contributions to theoretical chemistry, their new laws, their new generalizations, will provide the broader foundations upon which may be built a more satisfying scientific superstructure.

THE HARVARD TERCENTENARY

HARVARD UNIVERSITY will confer on September 18 honorary degrees on sixty-six of the principal speakers at the Tercentenary Conference of Arts and Sciences, which will be held from August 31 to September 19.

Those selected do not include those who have received honorary degrees from Harvard in the past. Among these are Albert Einstein, Robert A. Millikan, John Dewey, Henry N. Russell and William B. Scott.

Fourteen of the scholars to be honored are from the United States, twelve from England, ten from Germany, six from France, five from Switzerland, three from Italy, two each from Japan, Denmark, Scotland and Sweden and one each from the Netherlands, Argentina, Norway, Canada, Czechoslovakia, Austria, China and Australia.

The scientific men who will receive degrees with the descriptive statements sent to SCIENCE by the Harvard University News Office is as follows:

Edgar Douglas Adrian, Foulerton professor of the Royal Society and fellow of Trinity College, University of Cambridge, Nobel Prize winner in physiology and medicine, is an acknowledged leader of the modern school of neuro-physiologists, and has elucidated the neurological basis of sensation, the action of the various sense organs and the activity of nervous centers.

Edward Battersby Bailey, professor of geology at the University of Glasgow, Scotland, is a world leader among geologists, and has made important contributions dealing with the origin of mountains and the nature of volcanic and intrusive rocks.

Sir Joseph Barcroft, professor of physiology at the University of Cambridge, is a leading member of the group of British physiologists who have contributed largely during the past quarter of a century to knowledge of the blood as a carrier of oxygen and carbon dioxide.

Friedrich Bergius, of the Deutsche Bergin-Aktiengesellschaft, Heidelberg, Nobel Prize winner in chemistry, has developed processes in fuel technology which rank among the most important advances in chemical technology since the development of the method of making synthetic ammonia.

Niels Bohr, professor of physics at the University of Copenhagen, Nobel Prize winner in physics, is one of the world's outstanding figures in theoretical physics, and has pioneered in the study of atomic structure and the quantum theory.

Norman Levi Bowen, petrologist in the Geophysical Laboratory of the Carnegie Institution in Washington, is one of the world's leaders in the application of physical chemistry to problems in geology, having done notable work on igneous rock.

Elie Joseph Cartan, professor of mathematics at the University of Paris, one of the leading European mathematicians, has made important contributions to hypercomplex numbers and the theory of groups in the field of algebra, differential geometry and complex geometry in the field of geometry, integral invariants in the field of analysis and the theory of finite continuous groups.

James Bertram Collip, professor of biochemistry at McGill University, collaborated in the isolation of insulin and has done other important research in the chemistry of the blood, internal secretions, insulin, the parathyroid hormone and placental hormones.

Arthur Holly Compton, professor of physics at the University of Chicago, Nobel Prize winner in physics, is one of the world's outstanding figures in the study of cosmic rays and x-rays.

Peter Debye, professor of physics at the University of Leipzig, is one of the world's leading authorities in the field of polar molecules and has made many important contributions to physics.

Leonard Eugene Dickson, professor of mathematics at the University of Chicago, is one of the foremost algebraists and number theorists in the United States.

Sir Arthur Stanley Eddington, professor of astronomy and director of the observatory at the University of Cambridge, is one of the world's outstanding astronomers, and one of the great elucidators of modern astronomy and physics.

Hans Fischer, professor of chemistry at the Technische Hochschule in Munich, Nobel Prize winner in chemistry, is a world leader in the study of the structures of haemin and of chlorophyll, substances of extreme complexity and of the utmost importance in the understanding of animal and plant life.

Ronald Aylmer Fisher, professor of eugenics at the University of London, has made major contributions to the theory of statistics, has designed improved layouts for agricultural experimentation and has made a notable contribution to the genetical theory of natural selection.

Corrado Gini, professor of statistics and sociology at the University of Rome, is one of the most prominent sociologists, statisticians and demographers in the world.

Godfrey Harold Hardy, professor of mathematics at the University of Cambridge, is one of the most outstanding figures in mathematics, his principal contributions having been made in the fields of analysis and the analytic theory of numbers.

Ross Granville Harrison, professor of biology at Yale University, developed the method of embryonic transplantation which led to great advances in experimental biology, and has made important contributions to knowledge of the nervous system, symmetry and development after heteroplastic transplantation in the amphibia.

Werner Heisenberg, professor of theoretical physics at

the University of Leipzig, Nobel Prize winner in physics, is a world leader in theoretical physics, and has done notable research on atomic physics and the quantum theory.

Johan Hjort, professor of marine biology at the University of Oslo, is a leader in deep-sea exploration, in the study of marine biology, in its application to practical problems of the fisheries and in the coordination of marine investigations by the nations of Western Europe.

Sir Frederick Gowland Hopkins, professor of biochemistry at the University of Cambridge, Nobel Prize winner in physiology and medicine, is one of the world's foremost biochemists and has been a pioneer in several distinct fields, among them vitamins and the studies of chemical changes accompanying muscular contraction.

Bernardo Alberto Houssay, professor of physiology at the University of Buenos Aires, is a leader in the important and rapidly growing field of endocrinology and has brought forth much new information concerning the functions of the thyroid and adrenal glands, the pituitary gland, the parathyroids and the pancreas, and also the relations among these organs.

Pierre Janet, professor of psychology at the Collège de France, is generally regarded as having founded psychopathology as a separate discipline, and is recognized as one of the most distinguished psychologists and psychopathologists.

Charles Gustav Jung, professor of analytic psychology at the Technische Hochschule, Zurich, a great healer of mental ills, has been one of the important pioneers in the investigation of personality, has made notable studies of unconscious psychic processes and has continuously attempted to relate the results of his psychological researches to the dilemmas of modern man.

August Krogh, professor of zoophysiology at the University of Copenhagen, Nobel Prize winner in physiology and medicine, has made important contributions to the physiology of respiration and metabolism in man and the lower animals, to the physiology of the circulation of the blood, and to the chemistry of sea water in its relation to the nutrition of marine organisms.

Karl Landsteiner, of New York City, member of the Rockefeller Institute for Medical Research, Nobel Prize winner in physiology and medicine, has done as much as any living man to further the application of chemical methods and chemical concepts to the field of immunology, and is regarded as a great master who has founded a school of thought which has penetrated wherever immunologists are at work.

Andrew Cowper Lawson, professor of geology, emeritus, at the University of California, is one of the most stimulating and versatile leaders among American geologists, and his many important discoveries have had a world-wide influence in the advancement of geology.

Tullio Levi-Civita, professor of rational mechanics at the University of Rome, is one of the leading figures in mathematics, and has done notable work in hydrodynamics, theoretical dynamics and pure geometry.

Bronislaw Malinowski, professor of anthropology at the University of London, is a pioneer and leading exponent of functional anthropology, his inquiry into the Kula system and his studies of the Trobrianders having led to most that is significant in the modern development of social anthropology.

John Howard Northrop, of New York City, member of the Rockefeller Institute for Medical Research, has brought the study of enzymes within the fold of classical chemistry by their preparation in a crystalline state, and has made important investigations of the nature of enzymes and enzyme behavior.

Antonie Pannekoek, professor of astronomy at the University of Amsterdam, has made contributions of high merit in many fields of astronomy, notably in fundamental astrophysical investigations.

Jean Piaget, professor of the history of scientific thought at the University of Geneva, has done original research upon the developmental characteristics of the child mind, and has applied his findings to sociology in a way which has important implications for the field of social learning.

Leopold Ruzicka, professor of chemistry at the Technische Hochschule, Zurich, has successfully attacked many problems of particular difficulty in the field of the natural products, notably the chemistry of the sesquiterpenes, diterpenes, saponines and obietic acid.

Kiyoshi Shiga, of Kitasato Institute, Tokyo, internationally recognized as one of the great investigators of infectious diseases, is famous as discoverer of the cause of epidemic bacillary dysentery, by which discovery he opened a new field of investigation from which the whole world has benefited.

Filippo Silvestri, professor of general and agricultural zoology at the Regia Scuola Superiore de Agricultura, Portici, Italy, is one of the most eminent of living entomologists and has made outstanding contributions to science in many departments of entomology, both theoretical and applied.

Hans Spemann, professor of zoology at the University of Freiburg, Germany, Nobel Prize winner in physiology and medicine, is one of the world's leaders in biologic thought and has done notable research in the study of developmental mechanics, his work including a detailed study of the eye, the ear and the embryonic axis in the amphibia.

The Svedberg, professor of physical chemistry at the University of Upsala, is a Nobel Prize winner in chemistry whose skill in the solution of mechanical difficulties has enabled him to contribute enormously to chemistry and biology with the methods of physics, his crowning achievement being the development of the ultracentrifuge, which rendered possible the study of the size and shape of molecules whose dimensions were previously undetermined.

Otto Warburg, of the Kaiser Wilhelm-Institut für Zellphysiologie, Berlin, Nobel Prize winner in physiology and medicine, has given the world much of its knowledge concerning the chemical dynamics of metabolism in isolated tissues and cells.

OBITUARY

AUGUST F. FOERSTE

THE following minute, honoring the memory of Dr. August F. Foerste, was adopted at a meeting on June 1 of the faculty of Denison University:

In the death of August Frederick Foerste, Denison, A.B., 1887; Harvard, A.M., 1888, Ph.D., 1890; Heidelberg and Paris, 1890–1892; Denison, D.Sc., 1927, Denison University has lost another of her illustrious sons, a man whose work in science is known to paleontologists the world around.

Born at Dayton, Ohio, May 7, 1862, Doctor Foerste received his early education in the public schools of that city. While still a high school student he accumulated an herbarium of over 1,000 species of plants growing within a radius of ten miles of his home, and began collecting fossils at quarries near Dayton—a quest that led him later into fields afar, that made available to him for study fossils in many museums of America and Europe, and that brought him world-wide recognition as a geologist.

Unmindful of the lure of wealth and position, Doctor Foerste served as teacher in the Steele High School, Dayton, from 1893 until his retirement in 1932; his influence upon many generations of students is attested by the honor and respect they have shown him during these years. Since 1932 he has been connected with the United States National Museum at Washington, D. C., carrying on his studies of Ordovician and Silurian fossils. Of peculiar significance is the fact that his first papers appeared in the initial volume of the *Journal* of the Scientific Laboratories of Denison University in 1885, when he was a mature student of twenty-three years, and the page proof of his last paper (published in the April, 1936, issue of the same *Journal*) had passed through his hands the day before his sudden death, which occurred on April 23, 1936.

The faculty of Denison University adopts this resolution of respect honoring the memory of her worthy son, and directs that copies of it be sent to the family of Doctor Foerste and to SCIENCE.

F. J. WRIGHT
W. A. CHAMBERLIN
W. C. EBAUGH

GRANVILLE, OHIO

RECENT DEATHS AND MEMORIALS

PROFESSOR ARTHUR AMOS NOYES, since 1920 director of the Gates Chemical Laboratory of the California Institute of Technology, died on June 3 in his seventieth year. Dr. Noyes became assistant in the Massachusetts Institute of Technology in 1887 and was director of the research laboratory of physical chemistry from 1903 to 1920. He was president of the American Chemical Society in 1904 and president of the American Association for the Advancement of Science in 1927.

DR. IRA EUGENE CUTLER, professor of zoology from 1898 to 1934 at the University of Denver and thereafter professor emeritus, died on May 25 at the age of seventy-three years.

Nature reports the death at the age of forty-six years of Professor Harrower, who as professor of anatomy at the King Edward VII Medical College and consulting surgeon at the General Hospital, Singapore, rendered great services to medical education in Singapore, and of Sir Wilmot Herringham, consulting physician to St. Bartholomew's Hospital, vice-chancellor of the University of London in 1912-15, on April 23, aged eighty-one years.

ON the occasion of the visit to Bath on May 16 of the Section of the History of Medicine of the Royal Society of Medicine, Sir D'Arcy Power unveiled a memorial tablet of John Hunter on the wall of 12 South Parade, where Hunter lived in 1785, and Dr. F. G. Thomson delivered an address on some early Bath physicians and their times.

A BRONZE bust of Michael Faraday, by Mrs. Feridah Forbes, has been presented by Sir Robert Hatfield to the Royal Society, which hitherto had possessed a portrait only.

SCIENTIFIC EVENTS

THE BRITISH DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

THE annual report of the Department of Scientific and Industrial Research gives, according to the London *Times*, many indications of the growing importance which British industrial authorities attach to science.

The Advisory Council of the department, the chairman of which is Lord Rutherford, point to a very encouraging response to the offer which the department made last year to research associations of increased government support, provided the associations on their part obtained correspondingly increased contributions from the industries they serve. Negotiations with 13 out of 18 research associations in receipt of financial assistance from the department have been completed, and in every case offers of increased grants on a new basis have been made and accepted.

The Advisory Council states "that the immediate result has been that the association in question, as a whole, are already assured of a 30 per cent. increase in their resources as compared with those they

commanded 18 months ago. With one exception each of these associations now enjoys an income of at least £10,000, the minimum figure which, even in a small industry, we can accept for the income of an association whose future can be considered as assured."

While there is "encouraging evidence of the change being brought about largely by the whole-hearted efforts of enlightened leaders in our great industries," the Advisory Council still finds that the scientific outlook of some industries leaves much to be desired. "Neither in the directorates," it is stated, "nor among the technical and executive staffs is sufficient weight yet given to scientific attainment and experience; and until a radical change has taken place in this respect the position is bound to be that the industries as a whole will remain unable to obtain the full benefit of the results of scientific investigation.

"It is the progressive firms which engage in investigation and research, whether in their own laboratories or by sharing the burden of cooperative effort or in both ways, and these firms reap the benefits. From the national point of view it is vitally important to enlarge the circle of scientifically minded firms."

The report emphasizes the fact that science can be of service in the workshop as in the laboratory, and it is this link between the workshop and the laboratory which is the real essential for the application of advances in scientific knowledge.

The report gives a résumé of industrial advances resulting from the cooperation of science and industry, including an outline of the work of the British Scientific Instrument Research Association.

GRANTS IN AID OF RESEARCH OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SPECIAL endowment funds give the American Association for the Advancement of Science a limited income which, in accordance with the conditions of the donors, may be used in making small grants to individuals for the encouragement of research. A portion of these funds is now assigned through the medium of the state academies, and the allotment of another part rests with the committee on grants. For the coming year the sum placed at the disposal of the committee on grants is $2,000. The committee has favored recently the use of this fund to aid in the completion of important projects which have been carried to the point where but little is needed to finish the work.

Evidently from a total of such moderate size, individual grants must be narrowly limited in amount, but it has been found that smaller funds are often useful in meeting emergency needs which because of conditions can not be covered by other agencies. Requests for larger sums are beyond the power of the committee to consider. Special blanks may be secured from the office of the permanent secretary, Smithsonian Institution Building, Washington, D. C., on which those who desire may make application. It is essential that each application be supported by specific letters from at least two sponsors who are able to speak both of the applicant and of the project from personal acquaintance and are qualified to pass upon the worker and the proposed utilization of the grant. In accordance with action recommended at Boston and approved by the council, grants in aid of publication of research will not be considered under this heading.

The membership of the committee for the current year is as follows: Arthur H. Compton (1937) (for physics), University of Chicago; J. B. Macelwane (1936) (for geology), St. Louis University; Sam F. Trelease (1939) (for botany), Columbia University; Joel Stebbins (1939) (for astronomy), University of Wisconsin; McKeen Cattell (1938) (for medicine), Cornell University Medical College; Moses Gomberg (1938) (for chemistry), University of Michigan; C. C. Little (1937) (for zoology), Jackson Memorial Laboratory; Walter R. Miles (1936) (for psychology), Yale University. The committee prefers that all correspondence be addressed to the permanent secretary and not to individual members. The fiscal year of the association opens on October 1 and closes on September 30 following. All grants not utilized within the year normally revert to the treasury of the association on October 1.

Applications for grants for 1937 must be received at the permanent secretary's office in Washington, D. C., on or before October 30. Reports which are incomplete or late in arrival can not be considered for the year 1937. The report of the committee is laid before the executive committee and the council at the annual meeting in December, and payment of approved grants is made by the treasurer following that meeting. Unused portions of grants should be returned on October 1 of each year.

Publications including results obtained by virtue of the assistance rendered through grants should contain due acknowledgment of the aid furnished by the association. Recipients of grants are expected to make at least one report, which should be filed with the permanent secretary not later than October of the year for which the grant was made. In case completion of the report is delayed, notice should be sent to the permanent secretary's office and a statement of the results obtained in the research should be made at the time the report is filed.

HENRY B. WARD,
Permanent Secretary

THE FOURTH ANNUAL MEETING OF THE SOCIETY FOR RESEARCH ON METEORITES

THE Society for Research on Meteorites, an associated organization of the American Association for the Advancement of Science, will hold its fourth annual meeting at the University of California at Los Angeles on June 23 and 24. There will be two sessions a day, mainly for papers. On Tuesday evening there will be a dinner in Kerckhoff Hall for members and their guests, followed by an excursion to the Griffith Observatory and Planetarium, at which a lecture demonstration will be given.

The society was organized at Chicago in August, 1933, by Dr. Frederick C. Leonard, with a group of about fifty-five charter members, at the Field Museum of Natural History, the home of the most representative collection of meteorites in the world. Its purpose is "to promote the discovery, collection, investigation and preservation of meteorites, and to advance the science of meteorites, and related sciences, through the increase and diffusion of knowledge concerning meteorites." Although it welcomes to membership any one who is interested in meteorites, the majority of its members are professional men in the several fields of astronomy, geology, mineralogy, chemistry and physics. The organization is international in scope, with members in thirty-five states and seven foreign countries. Its "Contributions," edited by the president and the secretary from Los Angeles, are published serially in *Popular Astronomy* and are reprinted annually in fascicle form.

The second annual meeting was held at the University of California, Berkeley, in June, 1934, and the third at the University of Minnesota, in June, 1935. These meetings occurred in conjunction with the summer conventions of the American Association for the Advancement of Science.

The original officers of the society, who were elected at the organization meeting in Chicago and who will continue to serve until June, 1937, are: *President,* Dr. Frederick C. Leonard, University of California at Los Angeles; *First Vice-president,* Dr. C. C. Wylie, University of Iowa; *Second Vice-president,* Dr. W. F. Foshag, U. S. National Museum; and *Secretary-Treasurer,* Professor H. H. Nininger, Nininger Laboratory and Colorado Museum of Natural History.

THE SCIENTIFIC EXHIBIT OF THE AMERICAN MEDICAL ASSOCIATION

IN the scientific exhibit at the Kansas City meeting of the American Medical Association there were one hundred and fifty exhibits prepared by individuals under the auspices of the various sections of the Scientific Assembly; twenty exhibits in the Educational Classification were prepared by national organizations and government agencies; four exhibits from the headquarters of the American Medical Association and two special exhibits subsidized by the Board of Trustees.

Thirty-eight papers read before the various sections of the Scientific Assembly were also accompanied by material in the scientific exhibit, thus giving an opportunity to the individuals who had heard the papers to consult the authors and go over the work at leisure.

As reported in the *Journal* of the association, gold and silver medals were awarded in Class I for exhibits of individual investigation, which were judged on the basis of originality and excellence of presentation, and in Class II for exhibits which do not exemplify purely experimental studies and which were judged on the basis of excellence of presentation. The awards were as follows:

CLASS I

The gold medal to Charles B. Huggins, W. J. Noonan and B. H. Blocksom, department of surgery, University of Chicago, Chicago, for original investigation on the distribution of red and yellow bone marrow and the reticulo-endothelial system in the bone marrow.

The silver medal to G. C. Supplee and S. Ansbacher, research division, The Borden Company, New York, for original investigations on the development of pure lactoflavin, an entity of the water soluble vitamin B complex.

The bronze medal to Alvan L. Barach, Presbyterian Hospital, New York, for original investigations on the rôle of helium and oxygen in various types of dyspnea.

CLASS II

The gold medal to Rudolf Schindler, Marie Ortmayer and John F. Renshaw, University of Chicago, Chicago, for excellence of presentation of an exhibit on chronic gastritis as studied by gastroscopy.

The silver medal to John O. Bower, J. C. Burns and H. A. Mengle, department of research surgery, Temple University School of Medicine and General Hospital, Philadelphia, for an exhibit illustrating the treatment of spreading peritonitis complicating acute appendicitis.

The bronze medal to Hamilton Montgomery, Mayo Clinic, Rochester, Minn., for excellence of presentation of an exhibit illustrating the histopathology of various types of cutaneous tuberculosis.

SCIENTIFIC NOTES AND NEWS

DR. ARTHUR EDWIN KENNELLY, professor emeritus of electrical engineering at Harvard University and the Massachusetts Institute of Technology, received on May 28 the honorary degree of doctor of engineering on the occasion of the centenary of the Darmstadt Institute of Technology.

DR. E. D. MERRILL, administrator of botanical collections at Harvard University, was awarded the degree

of LL.D. at the seventy-third commencement of the University of California on May 23.

THE degree of doctor of science was conferred by Columbia University at commencement on Dr. William Francis Giauque. The citation made by Dr. Nicholas Murray Butler was as follows: "William Francis Giauque—born in Canada and graduated from the University of California in 1920; outstanding research worker in the field of thermodynamics and discoverer of a method for securing the lowest temperatures which have thus far been secured; professor of chemistry at the University of California."

THE doctorate of science "in recognition of his continuing scientific achievements and his contribution to the literature of biology" was conferred on June 10 by Western Reserve University on Dr. Francis Hobart Herrick, who has been a member of the faculty since 1888 and who retired with the title of professor emeritus of biology in 1929.

AT the commencement of the University of Montreal on May 29, the degree of doctor of science *honoris causa* was conferred on William Procter, of Bar Harbor, Maine. Mr. Procter is the organizer and director of the Biological Survey of the Mt. Desert Region.

AT its regular annual convocation on June 3, the University of Toronto conferred upon Dr. W. H. Collins the degree of doctor of science, *honoris causa,* in recognition of his contributions to geological science. Dr. Collins has been director of the Geological Survey of Canada since 1920.

AN oil portrait of Dr. Raymond Dodge, professor of psychology at Yale University, has been presented to the university by his friends and colleagues. The portrait, the work of Lloyd Bowers Embry, of the Yale School of the Fine Arts, has been hung in the Institute of Human Relations. A volume of scientific articles is now being prepared by leading psychologists in commemoration of Dr. Dodge's contributions to the field of experimental psychology.

A PORTRAIT bust of Dr. Anton J. Carlson, professor of physiology at the University of Chicago, a member of the faculty for thirty-two years, was formally unveiled on June 1 in the corridor of the building for physiology. Dr. Arno Luckhardt made the presentation. Vice-president Frederic Woodward, on behalf of the university, accepted the bust, which is executed in bronze by Mrs. Alice Littig Siems. It is the gift of a group of friends and former students.

AT the fifty-second annual commencement of the Case School of Applied Science, on June 1, the address was delivered by Professor Dayton C. Miller, on "The Spirit and Service of Science." This occasion marked his retirement from active duty after forty-six years in the faculty of Case School. In recognition of his distinguished services the trustees presented him with an illuminated testimonial designating him as honorary professor of physics for life. Dr. Miller also received the honorary degree of doctor of engineering for his contributions to architectural acoustics.

AT the close of the present academic year, Dr. E. P. Lyon, dean of the Medical School, retires from active service at the University of Minnesota. A correspondent writes: "During his administration, covering a period of twenty-three years, the Medical School has exhibited steady and continued growth. As a fitting tribute to his stimulating leadership, the alumni and faculty of the Medical School propose to establish in his honor the Elias Potter Lyon Medical Lectureship at the University of Minnesota. The fund for this purpose is to be raised through subscriptions by alumni, faculty, students and friends. Contributions to the Lyon lectureship fund may be sent to William T. Middlebrook, comptroller, University of Minnesota, Minneapolis."

DR. EDUARD UHLENHUTH, professor of anatomy, University of Maryland School of Medicine, received on June 9 the Van Meter Prize of the American Association for the Study of the Goiter for his thesis, "Isolation of the Thyreoactivator Hormone from the Anterior Lobe of the Bovine Pituitary Gland," which he presented before the annual session of the society.

DR. H. H. DONALDSON, member of the Wistar Institute of Anatomy, Philadelphia, was elected president of the American Neurological Association at the Atlantic City meeting. Other officers elected were: Dr. Samuel D. Ingham, of Los Angeles, and Dr. Edwin G. Zabriskie, of New York, *vice-presidents;* Dr. Henry A. Riley of New York, *secretary* and *treasurer;* and Dr. Bernard J. Alpers, of Philadelphia, *assistant secretary.*

DR. CYRIL N. H. LONG, director of the George S. Cox Medical Institute of the University of Pennsylvania Hospital, has been appointed professor of physiological chemistry at Yale University School of Medicine. He succeeds the late Lafayette B. Mendel as head of the department of physiological chemistry.

DR. JAMES C. GREENWAY, who has been director of the department of university health at Yale University since it was established in 1916, will retire and will be succeeded by Dr. Orville F. Rogers, who is now assistant director of the department. Dr. Rogers has been associated with the department since its organization and has been assistant director since 1921.

DUDLEY P. CRAIG, associate professor of mechanical engineering at Purdue University since 1921, has resigned to become professor and head of the department of mechanical engineering of the Colorado State College of Agriculture and Mechanic Arts.

DR. WARREN L. MCCABE, associate professor of engineering at the University of Michigan, has been appointed professor of chemical engineering at the Carnegie Institute of Technology.

DR. MCKEEN CATTELL has been appointed associate professor of pharmacology in charge of the department at Cornell University Medical College, New York City.

THE Charles Mickle fellowship of the University of Toronto has been awarded to Dr. Donald D. Van Slyke, member of the Rockefeller Institute for Medical Research, in recognition of his methods of blood analysis, gasometric micro-analysis and his work on respiratory and renal reactions, diabetes and nephritis. This fellowship provides the annual income from an endowment fund of $25,000.

THE Electrochemical Society has awarded the eighth Weston fellowship of $1,000 to Dr. Henry B. Linford, of Pullman, Wash. Dr. Linford will continue his studies on the electrochemical properties of the elements of the fourth group in the periodic table, the work to be done under the direction of Professor Colin G. Fink at Columbia University.

J. D. FIGGINS has been appointed to the directorship of the Amanda Bernheim Memorial Museum, in connection with the Isaac W. Bernheim Foundation, near Louisville, Ky. After serving as director of the Colorado Museum of Natural History for a period of more than twenty-five years, Dr. Figgins became director of the foundation. The museum building will be built on high ground on a 13,200 acre tract of forest, situated twenty-seven miles south of the city of Louisville. It is planned for the illustration of the natural history of the Americas. Immediate preference will be given to Kentucky and the region lying south of the Ohio River and east of the Mississippi River. The museum will not be erected until a number of exhibits are ready for installation, among these being habitat groups of the prehistoric Indians of Kentucky.

DR. ROBERT OLESEN, specialist in goiter research, formerly of Cincinnati, has been appointed assistant surgeon general, under Dr. Thomas Parran, who recently succeeded Dr. Hugh S. Cumming as Surgeon General of the U. S. Public Health Service. Dr. Olesen will assume the post formerly held by Dr. Ralph C. Williams, who has been assigned to a place on the Texas Centennial staff.

HENRY TEUSCHER, for the past three years dendrologist at the New York Botanical Garden, left on May 1 for Canada, where he has become superintendent and chief horticulturist of the newly established Botanical Garden of Montreal. His work there includes the planning and preliminary planting and construction of the garden, of which Frère Marie-Victorin is scientific director.

MME. IRENE JOLIOT-CURIE has been appointed by M. Blum, premier of France, Under Secretary of State for Scientific Research in the cabinet.

DR. E. B. MAINS, director of the herbarium of the University of Michigan, and Dr. C. L. Lundell, assistant curator, will spend the summer in the mountains of the El Cayo District of British Honduras. A study of the plants of the region will be made as part of the biological survey of the Maya area being made by the University of Michigan in cooperation with the Carnegie Institution of Washington.

DR. ROBERT HEGNER, professor of protozoology in the Johns Hopkins University, will sail for Europe on June 17. He will spend the summer in Spain and Portugal studying the control of malaria and will attend the International Congress on Malaria in Madrid in October.

DR. P. W. BRIDGMAN, Hollis professor of mathematics and philosophy at Harvard University, and Dr. Joel H. Hildebrand, professor of chemistry at the University of California, have been invited to introduce two phases of discussion at the annual meeting of the Faraday Society, in Edinburgh, Scotland, this autumn. Dr. Bridgman will introduce the discussion on "Intermolecular Forces in Pure Liquids" and Dr. Hildebrand the discussion on "Intermolecular Forces in Solutions." The meeting will be held from September 24 to 26.

DR. KARL T. COMPTON, president of the Massachusetts Institute of Technology, will address the graduates of Middlebury College on the occasion of its one hundred and thirty-sixth commencement on June 15.

DR. EDWARD KASNER, professor of mathematics at Columbia University, recently lectured at the University of North Carolina and at Duke University on "New Groups of Element Transformations."

THE third annual lecture under the Arno B. Luckhardt Lectureship in the School of Medicine of the University of Chicago was given on May 21 by Dr. Walter J. Meek, of the department of physiology of the University of Wisconsin, on "A Present Day Concept of Shock." This lectureship was established in the School of Medicine by the Delta Chapter of Phi Beta Pi.

PROFESSOR R. ADAMS DUTCHER, head of the department of agricultural and biological chemistry of the

Pennsylvania State College, delivered the commencement address at the School of Agriculture and Mechanic Arts, at Mayaguez, Puerto Rico, on May 25. After his return he will give a series of lectures on nutrition at the summer session of the Oregon State College.

AT the annual meeting of the College of Medicine of the University of Illinois Chapter of Sigma Xi, John Bellamy Taylor, of the General Electric Company, delivered the lecture on "The Electric Eye and the Human Eye." Invitations to attend the lecture were extended to the Northwestern Chapter and the Chicago Chapter, as well as to the senior class of the College of Medicine.

THE ninth annual meeting of the Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council will be held at the Massachusetts Institute of Technology on November 6 and 7. Contributions to the technical program, reports on research in progress and discussion in the field of dielectric theory and insulation should be sent to Dr. J. B. Whitehead, chairman, the Johns Hopkins University, Baltimore.

ATLANTIC CITY, N. J., has been selected for the annual meeting of the American Medical Association for 1937.

THE German Society of Naturalists and Physicians will hold its annual meeting from September 21 to 24.

THE annual meeting of the International Society of Medical Hydrology, which is open to non-members on payment of a fee of £1, is to be held this year in Austria, from October 10 to 16. The opening ceremonies and the first medical discussion will take place in Innsbruck, by invitation of the university and of the municipality; the party will then proceed to Badgastein, visiting Hofgastein, and from there to Salzburg. An optional one-day motor tour of the Salzkammergut follows the meeting and there will also be optional excursions to Vienna and Budapest, beginning on the seventeenth. The two principal subjects for consideration are: "The Spa Treatment of Disorders of Old Age," to be introduced by Sir Humphry Rolleston, followed by Professor Pap (Budapest) and Dr. J. Schneyer (Badgastein), and "Radio-Activity in Medicinal Waters," studied in its physical, physiological and clinical aspects by Dr. Penkava (Prague), Dr. Cerke (Badgastein) and Drs. Pierret and Stieffel (La Bourboule and Plombières). Supplementary papers may be offered and there will also be an open session for communications on any hydrological subject. A party will be formed to travel from London on October 9. The anticipated costs of participation are, if a party of fifteen can be formed, £10 to £11 return fare to Innsbruck and back from Salzburg, plus the "inclusive charge of 180 Austrian schillings (circa £7) for traveling, accommodation, board, etc., after arrival at Innsbruck. Fuller particulars may be obtained from the General Secretary, International Society of Medical Hydrology, 109, Kingsway, London, W.C.2.

Nature reports that under the presidency of the Earl of Clarendon, governor general of the Union of South Africa, the South African Association for the Advancement of Science will hold its thirty-fourth annual session from October 5 to 10 in Johannesburg. The meeting coincides with the celebrations connected with the jubilee (fifty years) of Johannesburg and with the holding there of the Empire Exhibition. Sectional presidents and the subjects of their addresses follow: A, Dr. E. J. Hamlin, city engineer, Johannesburg, "The Researches of a City Engineer's Department"; B, Professor E. D. Mountain, professor of geology and mineralogy at Rhodes University College, Grahamstown, C.P., "Minerals"; C, Professor John Phillips, professor of botany in the University of the Witwatersrand, "Biology and Industry: with Special Reference to Plant Biology and the Mining Industry"; D, Dr. R. Bigalke, "The Naturalization of Wild Animals with Special Reference to South Africa"; E, Professor M. R. Drennan, professor of anatomy in the University of Cape Town, "Human Growth and Differentiation"; F, Dr. I. D. MacCrone, lecturer in psychology in the University of the Witwatersrand, "The Problem of Race Differences." Professor L. Fouché, professor of history in the University of Witwatersrand, will deliver a public evening lecture on the history of the Witwatersrand. Visiting scientific workers will be made honorary members for the session.

THE American Eugenics Society, founded by Professor Irving Fisher, of Yale University, will move its headquarters from New Haven to the Rockefeller Center in New York City. The new offices will be in charge of Rudolph Bertheau.

ROCK formations of southeastern Wyoming and adjacent Colorado will be studied by field workers in geology in connection with the Columbia University Summer Session. From the headquarters camp in the Medicine Bow Mountains, trips of several days' duration will be made beginning on June 20 and continuing to July 25. Professor Samuel H. Knight, of the University of Wyoming, will direct the research. Preceding this work in Wyoming, Dr. G. Marshall Kay, Dr. Horace N. Coryell and Dr. Philip Krieger, of Columbia University, will lead field trips in the Pre-Cambrian and Paleozoic rock section of eastern North America. A second party will observe stratigraphic sections and structure of areas along the St. Lawrence

River east to Gaspé for three weeks. In Virginia and West Virginia, one of the most typical non-glaciated areas of the eastern United States will be studied by students of geography under the direction of Professor Frank J. Wright, of Denison University, Granville, Ohio.

DISCUSSION

SOIL TEMPERATURES AT BOZEMAN, MONTANA, DURING SUB-ZERO WEATHER

DURING the period commencing on January 25, 1936, at Bozeman, Montana, there was experienced the coldest and most extended spell of sub-zero weather ever to be recorded at the Experimental Farm. These records have been maintained for fifty-three years. This cold snap swept over practically all the northern and central United States east of the Rocky Mountains, inflicting much personal hardship on individuals and communities and disrupting all forms of transportation. Not only Bozeman but many places widely scattered over the whole country registered record lows.

Throughout the month of February, at Bozeman, the soil temperature apparatus operated by the Department of Entomology provided many interesting data, emphasizing once more what has been so often forcibly impressed on observers—the great insulating effect of a snow covering.

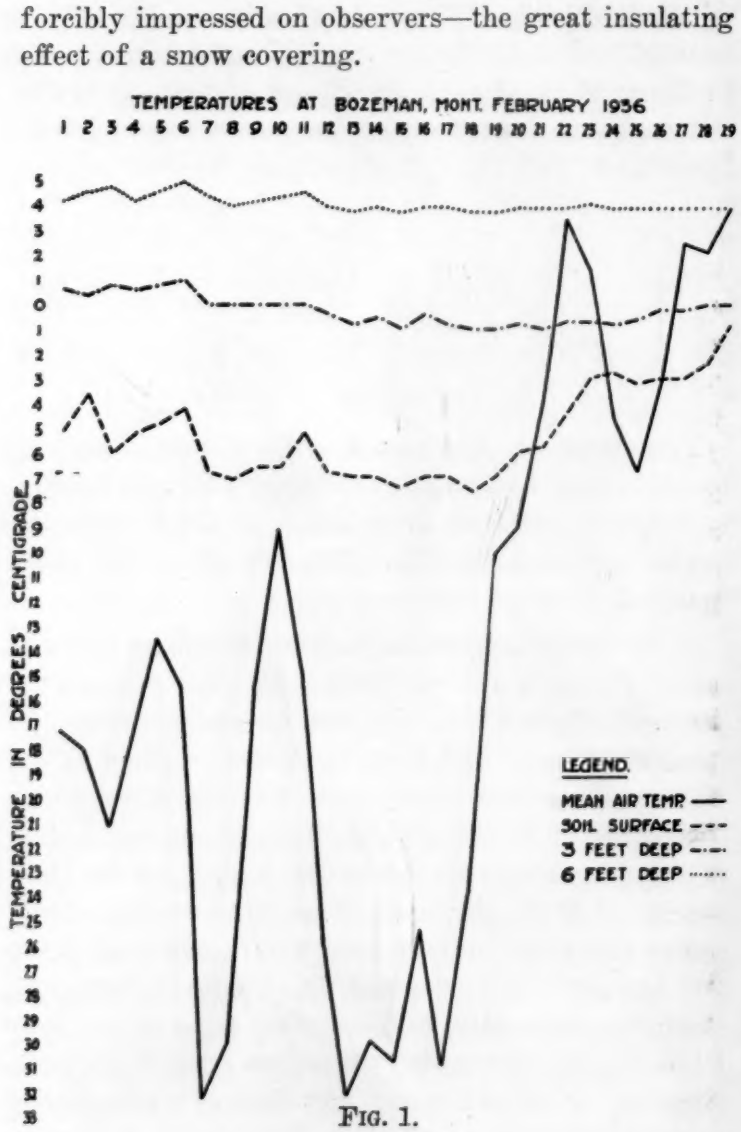

FIG. 1.

From a perusal of the graph (Fig. 1) showing conditions in soil, snow and air, it will be seen that the frost line reached three feet and stayed there for 23 days, and at four feet the temperature was only 1.0° C. above freezing. This is the first time during the six years covered by this study that the frost line has penetrated so far and for such a lengthy period. During all February the snow covering over the instruments varied in depth from 8 to 15 inches. This insulation resulted in a very small fluctuation of temperature under the snow in spite of great variations of air temperature, the minimum temperature at the soil surface being only –7° C. The minimum air temperature for the month was –41.7° C. Also between the minimum of +1° C. at four feet in depth and the soil surface there was only an 8-degree gradient, so that plant and animal life in that first four feet were not subjected to abnormally cold conditions.

It is unfortunate that similar records are not being obtained at more stations throughout the country. Were comparable data available from stations widely scattered and in greatly varying climatic belts, it might be possible to correlate the information so obtained, as regards winter soil temperature distribution, with the distribution of plant and surface-living and subterranean animal life. Certainly such information would be of marked importance in studying the winter hardiness of economic forms of plants and animals.

G. ALLEN MAIL

MONTANA STATE COLLEGE

THE DODGE, NEBRASKA, "FIREBALL"

BETWEEN 10 and 11 P. M. on the evening of June 24, 1935, farmers who live in the vicinity of the Carl Iske farm, 8½ miles south of Dodge, Nebraska, reported intense light entering through windows on all sides of the house, followed by a loud explosive noise. The day had been hot, with a thunder-storm a short distance to the northward, but no rainfall in that immediate vicinity.

A few days later, a hole was found in the earth in a cornfield which slopes gradually to the south, with clay subsoil. A party, headed by Police Commissioner Frank Meyers, of Omaha; Professor J. L. Cannon, of Creighton University, and Professor D. W. Crouse, of Midland College, had charge of an excavation of the hole, this work being begun on July 22.

The dirt was found thrown back from all sides of the 8-inch hole at the center for a distance of about 3 feet and heaped up about 6 inches above the level of the surrounding ground. The hole extended downward 8 feet almost vertically, with an average diameter of 8 inches, then became smaller for the next 7 feet and varied somewhat from the perpendicular. At a depth of 15 feet the diameter had been reduced to about 4 inches and branched out in 3 directions into 2-inch holes, which were followed for 3 or 4 feet into the bank where they disappeared. At this level the clay became very moist, and it was evident that the water level was being approached.

The clay showed signs of fusion at a number of points, and the inside of the hole had a corrugated appearance, as though moist clay had been forced violently back by high pressure. No evidences of any material of different composition than the clay itself were found, and there were no traces either in the hole or outside of it of material which might have been of meteoric origin.

The conclusion reached, therefore, is that, although eye-witnesses held to the opinion that a meteorite struck the earth, the hole was caused by a thunderbolt and not by material of celestial origin, for there is no record of a small meteorite ever having penetrated the earth to such a depth. The size and length of the hole are phenomenal, however, in the records of electrical discharges.

J. C. JENSEN

NEBRASKA WESLEYAN UNIVERSITY

TERMITE DISTRIBUTION IN THE UNITED STATES

DR. A. E. EMERSON'S[1] current reference in SCIENCE to the somewhat more common occurrence of termites in the eastern United States than has been indicated by some observers prompts the following confirmation. *Reticulitermes flavipes* (Kollar) was secured in considerable abundance from several sources within a five-mile radius of New Haven in 1921–23. Individuals were taken from colonies in the ground and from fallen tree trunks in partial states of decay, soldiers, workers and winged adults being present. Specimens were transferred to the Osborn Zoological Laboratory, where they were kept in large covered crystallization dishes in pieces of the original wood, moisture being supplied by wet filter paper. Ample numbers were available for a study of the protozoan fauna of the intestine.

On April 20, 1933, nearly all of a colony of termites, seemingly *Reticulitermes flavipes,* was recovered from a stand of hard and soft wood on Mill Road about a mile from the village of Durham, New Hampshire. Examination of the protozoan content of the gut showed it to be similar to that found in New Haven.

Banks and Snyder[2] print a map of distribution for *R. flavipes,* which shows that they were found in southwestern Maine, southeastern New Hampshire and in Connecticut. The monograph reports them from Lyme, Connecticut (Greene), from Kingston, Rhode Island (Barlow), and from several towns in and around Boston. The authors state that "This termite is widespread in the eastern United States, its geographical distribution being from (Canada?), Kittery, Maine (Thaxter), southward to the Florida Everglades."

Dr. Emerson mentions that *R. flavipes* was also collected at "New Castle, Lincoln County, Maine," referring undoubtedly to the town of *Newcastle,* located some eighteen miles from Bath. He adds "Other new northern records furnished by Dr. T. E. Snyder . . . are Bellows Falls, etc.," which may imply that these termites have been reported only once from Maine. This does not seem to be the case. Casual attempts to discover them in this section of the state have thus far proved unsuccessful, however.

CHARLES EARL PACKARD

UNIVERSITY OF MAINE

FEDERAL RELIEF LABOR AND PALEONTOLOGY

FOR the two years just past, the Museum of Paleontology of the University of California has been the sponsor of a project involving the use of fourteen to eighteen Federal Relief workers engaged in the various phases of museum duties. During the current year, the labor cost has been borne by the Works Progress Administration. The object of the present paper is to place on record the nature of the work done, the adaptability of the workers to it and the possibility of other similar public institutions taking advantage of this type of help.

At Berkeley, the Museum of Paleontology houses primarily a research collection of fossil vertebrates, invertebrates and plants. As in related museums, the primary problem is the quick and adequate preparation, housing and cataloguing of newly acquired material. And as in most museums, the permanent staff is small and the duties manifold, with the result that many specimens or even faunas are, of necessity, half prepared or still in the field wrappings. Moreover, housing problems become acute, curatorial difficulties increase and research is hindered.

When Federal Relief workers became available to the various units of the University of California, it

[1] SCIENCE, 83, 410.

[2] U. S. Nat'l Mus. Bull. 108: pp. 45, 150–161, 1920.

was decided that use of these workers in the Museum of Paleontology, especially in the preparation of fossil bone, would be a worthwhile experiment. That the experiment was successful is borne out by the fact that the Federal Aid staff has advanced the routine Museum program by ten years.

Since the careful preparation of paleontologic material requires experience and some native dexterity, and since trained men in this field of endeavor are few indeed, our first problem was to give inexperienced people from all walks of life a short period of instruction. The results were most gratifying, and while a few of the earlier workers were unable to grasp the technique, others who could were secured and now a staff of ten experienced preparators are working daily and most of them can be trusted on such delicate jobs as the preparation of skulls in hard matrix. Incidentally, former dental technicians lend themselves admirably to this type of work.

In other phases of museum work, Federal Relief workers have proved equally advantageous, especially those with college training. These phases include the preparation of specialized bibliographies, the translation of paleontologic writings and the typing therefrom of manuscripts to be bound into the library, the uniform relabelling of the storage trays (here a former draftsman is used), the numbering and cataloguing of specimens, the casting in plaster of replicas of types and other specimens for exchange purposes, and the preparation of thin-sections of bone, shell and rock.

The making of thin-sections is a time-consuming task; but one which is indispensable to many kinds of paleontologic research. The man employed at this task has become expert and the fruits of his labor, as well as of all those employed on the museum project, become a permanent acquisition to the scientists of the world and provide a wealth of research material for a generation of graduate students.

It should be emphasized that in no case have Federal Relief workers replaced museum employees, and the nature of the work done by them makes it wholly non-competitive with private enterprise. The results of their labor are simply additive to the normal museum program.

V. L. VANDERHOOF

BERKELEY, CALIFORNIA

SCIENTIFIC BOOKS

GENETICS

Genetics. By H. S. JENNINGS. W. W. Norton and Company, New York. $4.00. $8\frac{1}{2} \times 5\frac{3}{4}$; xii + 373; 1935.

PROFESSOR JENNINGS'S book is, in his own words, "an attempt to present the fundamental features of Genetics: those features of which every educated person should have knowledge." This presentation is made with the scrupulous accuracy we have come to associate with Professor Jennings's writings. A striving for clearness and simplicity of statement is evident throughout, and "every educated person," whether biologically trained or not, can understand it, although, as a non-biological friend put it after reading a chapter in the book, the layman "will have to move his lips as he reads," in some spots. The very laboring for simplicity makes the book a bit repetitious and tedious to the experienced biologist, but since his kind is not the audience aimed at, this can not be regarded as a fault. All biologists, however, will be thankful for Professor Jennings's lucid digest of the scattered and rapidly accumulating literature on Drosophila, and the presentation of its salient facts in a simple straightforward manner which even the beginning student can easily read and understand. In this connection one misses only the supplementary evidence concerning the nature and the location of genes that might have been adduced from the remarkable behavior of the salivary chromosomes in such forms as *Drosophila* and *Sciara*.

The general plan of the book departs from the conventional in that the underlying mechanism of heredity —the nature of the germinal constituents—is discussed before the usual generalities of genetics are reviewed. While this is unquestionably the logical approach, how such a method will work out in actual class usage, particularly with large classes, is a matter that will doubtless be watched with much interest by teachers of genetics.

Since the author is so obviously striving for ease of comprehension, it might be pointed out that this would be much facilitated if the secondary headings within chapters—particularly such as chapter 9—were set up in bold-faced type instead of the same type as the text.

In the survey of the more general relations of genetics the author makes frequent allusion to practical, and above all to human problems, although in the case of man he is very cautious in his affirmations and carefully steers clear of anything savoring of propaganda. He is apparently more impressed with what we don't know about human inheritance than with what we do know.

The final chapter dutifully reminds us of our real ignorance of the nature of progressive evolution, pointing out that our main accomplishment in the study of the mechanism of variation has been recognition and in some cases the production of recessive and

ostly harmful mutations. These are of a kind that ould seem unlikely to have served as steps in that rogressive evolution which has yielded the multiicity of complex, efficient living forms which surund us to-day.

The book is one which every biologist interested in e least in genetics should possess, and one which any telligent layman can read with interest and profit. may also well take a prominent place among textooks of genetics for class use.

M. F. GUYER

UNIVERSITY OF WISCONSIN

BIOLOGY OF NORTH EUROPEAN SEA FISHES

aturgeschichte und wirtschaftliche Bedeutung der Seefische Nordeuropas. Ernst Ehrenbaum, 337 pp., 276 illus.; E. Schweizerbartsche Verlagsbuchhandlung, Stuttgart, 1936. Price, unbound, 33, R.M., outside of Germany.

THE literature of the rapidly developing science of sheries-biology has now grown to dimensions so rmidable that no one, other than a specialist, can ope to keep abreast of it. Especially needed have en convenient handbooks, in which fishermen of difrent nations, and others concerned with the fishing dustry, could find concise accounts of what is known the life-histories and commercial exploitation of the rious fishes to be caught on the fishing grounds; not ly off their own coasts, but on others farther distant, which their fleets also repair. The volume by Dr. hrenbaum, here reviewed, was prepared expressly to l this want for the coasts and fishing banks of orthern Europe as a whole, and may be said to do so, dmirably. The book appears as Vol. II (one other olume has already been published) of the compendis "Handbuch der Seefischerei Nordeuropas," proected under the combined editorship of Drs. H. übbert and E. Ehrenbaum. And Dr. Ehrenbaum's minence as an ichthyologist, with the active part he as long taken in the international investigations of e sea fisheries, gives it authority.

In it we find accounts of nearly all the fish-species be found in North European seas, including many nown there from occasional captures, only. Being rankly dedicated to the service of those employed in e fishery trades, the fullest accounts are (naturally nd rightly) those of the species that support the most mportant fisheries; of which that of the herring may rve as example.

Here the reader finds the common names by which e fish is known in various languages, followed by a rief systematic description, including color and size. eographic distribution on the two sides of the Atlane next receives a paragraph, including mention of the closely related herring of the North Pacific. The life-history is treated in greater detail, covering such topics as food, adult migrations, breeding, type of eggs, length of incubation at different temperatures and successive larval stages; the latter illustrated from the author's own earlier investigations. Later growth-rate is next traced, with discussion of the relative abundance of different year classes, a matter of prime import to fishermen in the northern countries of Europe. After mention of parasites and enemies—the herring must be seriously decimated by the latter—Dr. Ehrenbaum discusses the question of local races, including the movements of schools of different racial origins. The account ends with a statement of the amounts of herring caught in different years, at different localities and seasons, of the methods of the fishery in different countries, and of the states in which herring from different sources are marketed.

The accounts of the other species of commercial importance follow these same general lines, chief emphasis being laid in different cases on the phases in the life history that are either the best-known or that seem the most interesting from one standpoint or another. Thus the account of the eel is largely devoted to its growth in fresh water, structural changes that precede sexual maturity, breeding migrations of the adults downstream and out to mid-ocean, situation of spawning grounds, and return journeys of the young eels to the coast and upstream—matters that have so greatly aroused scientific interest of late years. Similarly, in the case of the cod, special attention is paid to migrations as proved by tagging experiments, also to the regional distribution of the fishery; while, for the plaice, the question of overfishing in the North Sea is kept to the fore.

Species not regularly fished receive briefer mention. If common enough to be familiar to fishermen, or to other frequenters of the coast—the labrids, for example—the accounts include (as before) the common names, brief systematic characterization, summary of distribution and reference to what little may be known as to life history. Finally, species so rare that only an occasional specimen is taken are passed over with bare mention or with brief comparison with their better-known relatives.

Outstanding features of the book are the beautiful illustrations of all the familiar species and of most of the less familiar ones also, chosen with discrimination from various sources. With these, it should be easy for any one at all familiar with the sea fishes of northern seas to name the species he has caught or has found in the fish market; or to name the genus at least in the case of rarities. Specific determination of these last would in any case be a task for the systematic ichthyologist. Since the book is not dedicated to the

latter, no objection can be raised to Dr. Ehrenbaum's decision—stated in the introduction—to renounce any attempt at classification intended to express the most modern taxonomic views in favor of an older arrangement, apt to be more familiar to his readers. In this, like most European ichthyologists, he uses genera in a more inclusive sense than is usual with his American colleagues. Haddock and coalfish, for example, are included in the old genus Gadus; the European shad in Clupea.

Bibliography is limited to titles especially important from the standpoint of the volume in hand; there is an adequate index.

All in all, the reviewer can have little but praise for Dr. Ehrenbaum's book, for which one may predict favorable reception in America as well as in Europe, for many of the species discussed occur on both sides of the Atlantic.

HENRY B. BIGELOW
HARVARD UNIVERSITY

SOCIETIES AND MEETINGS

THE ILLINOIS STATE ACADEMY OF SCIENCE

THE twenty-ninth annual meeting of the Illinois State Academy of Science was held at the Senior High School, Quincy, Illinois, on May 1 and 2. The meetings were attended by nearly 800 persons, including members of the Junior Academy, which held sessions of its own as a part of the annual meeting.

At the general session on Friday morning the retiring president, Dr. C. D. Sneller, of Peoria, gave an address on "The Mucous Membrane of Our Nose, Throat and Ears"; Dr. T. E. Musselman, of Quincy, talked on the subject, "The Contributions of an Amateur to Science." These addresses were followed by a symposium on "The Tropics," sponsored by the geography section of the academy. The principal speakers at this symposium were Dr. W. H. Haas and Dr. L. R. Crandall, both of Northwestern University. For the public lectures given on Friday evening Dr. Fay-Cooper Cole, of the University of Chicago, addressed the Junior Academy members on the subject, "Digging in Our Own Backyard," while the annual public lecture of the academy was given by Dr. Andrew Conway Ivy, of Northwestern University Medical School, who spoke on the topic, "The Endocrine Glands."

The Friday afternoon program consisted of the presentation of 119 papers before nine sectional meetings. On Saturday the sessions of the academy were made up of field trips. These trips were four in number and each drew a good attendance. The geological trip, led by Dr. M. M. Leighton, chief of the State Geological Survey, Dr. George E. Ekblaw, also of the State Geological Survey, and Father Callistus Bifoss, of Quincy College, visited sites of geological interest in the vicinity of Quincy. An industrial trip, under the direction of Mr. M. Finn, of Quincy, made an intensive tour of some of the manufacturing plants located in Quincy. An anthropological trip, led by Mr. Louis Dearr, Jr., and Mr. O. D. Thurber, both of Quincy, visited and studied the various types of Indian burial mounds in the vicinity of Quincy. A biological trip, under the direction of Dr. T. E. Musselman and Mr. Robert Evers, both of Quincy, visited the Coe creek beds and the commercial mushroom beds, besides other points of biological interest in the region of Quincy.

The following resolutions were adopted by the academy:

Resolved, that we express our appreciation and admiration for the fine work being done by the Junior Academy and for its exceptional line of exhibits, and that we commend Miss Mable A. Spencer, its chairman, Mr. Louis A. Astell, the committee and all others who are promoting this work among the young people of Illinois.

Resolved, that we heartily commend the Illinois State Geological Survey, for its research program calculated to discover further uses of the mineral resources of the state and thus to increase employment; and that the State Academy urges that the federal and state governments encourage such research in every possible way.

Resolved, that the State Academy favors a wise policy of conservation that, while ministering to present needs will pass our resources on to future generations, and that we commend research having this end in view.

Because of the great inadequacy of space and ill-suited laboratory conditions and facilities of the State Geological Survey and the State Natural History Survey for research on the natural resources of the state, we urge that every possible consideration be given by the State General Assembly and the governor of the state to the construction of a State Natural Resources Building for this work.

The officers elected for the ensuing year are:

President, C. L. Furrow, Zoology, Knox College, Galesburg; *First Vice-president,* Harold R. Wanless, Geology, University of Illinois, Urbana; *Secretary,* Wilbur M. Luce, Zoology, University of Illinois, Urbana; *Treasurer,* George D. Fuller, Botany, University of Chicago; *Editor,* Dorothy E. Rose, State Geological Survey, Urbana.

The next annual meeting will be held at Rockford College, Rockford, Illinois, on May 7 and 8, 1937.

WILBUR M. LUCE,
Secretary

THE SOUTH CAROLINA ACADEMY OF SCIENCE

THE South Carolina Academy of Science held its annual meeting at Winthrop College, Rock Hill, on April 25. At the business meeting, the following officers were elected for the ensuing year:

President, Professor A. C. Carson, University of South Carolina.

Vice-president, Dr. J. E. Mills, Sunoco Products Company, Hartsville, S. C.

Secretary-treasurer, Dr. F. W. Kinard, Medical College of South Carolina.

Executive Committee: Dr. Roe E. Remington, Medical College of South Carolina; Professor Franklin Sherman, Clemson Agricultural College; Professor Mary New, Greenville Womans College; Dr. Bruce Mayne, U. S. Public Health Service, State Hospital, Columbia, S. C.; Dean S. B. Earle, Clemson Agricultural College.

Librarian, J. E. Copenhaver, University of South Carolina.

A program of twenty-six papers was given. About 50 members and visitors attended. One of the outstanding features of the meeting was the awarding of the Phipps and Bird gold medal, for the best paper presented, to Drs. F. W. Kinard and F. N. Martin, Jr., Medical College of South Carolina. The subject of their paper was: "A Study of Blood Histamine in Normal and Burned Dogs." This paper will be sent in competition with similar winning papers from the Academies of Georgia, North Carolina and Virginia for a $100 prize. The next two best papers will be given $25 each. These medals and prizes are given by Phipps and Bird, Inc., Richmond, Virginia, distributors of chemicals and laboratory apparatus.

The academy will meet at the University of South Carolina, Columbia, next year.

J. E. COPENHAVER,
Retiring Secretary and Treasurer

THE VIRGINIA ACADEMY OF SCIENCE

THE Virginia Academy of Science held its fourteenth annual meeting on May 1 and 2 at the Virginia Military Institute at Lexington, Va., with a registration of 408.

The address of the president, Professor Ida Sitler, of Hollins College, was on the subject of a Science Museum, which is a very live subject with the academy at this time. Dr. C. C. Little, of Bar Harbor, Me., gave the public address at the Friday night meeting on the subject of "Heredity in Experimental Cancer." One hundred and forty-two papers were presented before the sectional meetings.

The regular academy prize of fifty dollars and the recently established Jefferson Gold Medal were both awarded to Dr. Alfred Chanutin, of the University of Virginia, for a paper entitled "The Effect of Whole Dried Meat Diets on Renal Insufficiency Produced by Partial Nephrectomy."

The president for the coming year is Dr. H. E. Jordan, of the University of Virginia, the president-elect is Professor D. Maurice Allan, of Hampden-Sydney College, and the newly elected member of the council is Dr. Edward Steidtmann, of the Virginia Military Institute.

The next meeting will be held at the University of Virginia on the first Friday and Saturday of May, 1937.

E. C. L. MILLER,
Secretary

SPECIAL ARTICLES

THE CULTIVATION OF LARGE QUANTITIES OF ADULT TISSUE IN FLUID MEDIA

IF a technique could be devised for keeping large quantities of adult tissue in a state of functional survival for considerable periods in fluid media, it would provide a means of studying a great variety of physiological problems that could not be approached by using either cell strains or embryonic material. It would also rule out the necessity of having to contend with a plasma coagulum as an integral part of the culture medium. This has been accomplished. It is the purpose of the present communication to describe the procedures that have been developed.

The tissues are cut into fragments of such a size that it requires about 75 to weigh 100 mg. The cutting is done with cataract knives on a glass plate. For most purposes, it is unnecessary to weigh the tissue for each experiment. With a little practice, it is possible to cut uniform fragments and to judge their total weight by the number prepared. Thus, each culture comprising a given series receives the same number of fragments. The total number of fragments (50 to 75) intended for each individual culture are placed in separate depression slides containing glucosol[1] and allowed to stand until all the fragments have been prepared for a given experiment. After several changes of glucosol, they are ready to be transferred to their respective flasks. The flasks[2] are of the H-8 type

[1] "Glucosol" is a modified Tyrode solution that has been used in this laboratory for many years. It has the same composition as Tyrode solution, except that the $NaHCO_3$ is omitted.

[2] These flasks are 8 cm in height, have a flat bottom 5 cm in diameter and a capacity of 65 to 70 cc. The neck is eccentric, oblique (45°) and has an opening 1 cm in diameter. The oblique neck and the small opening offer protection from contamination when the flasks are unstoppered. The eccentric position of the neck renders it possible to examine the contents with the aid of the

designed three years ago by Carrel for the cultivation of viruses. These flasks are particularly sturdy, simple in design and of large capacity (65 to 70 cc). As a rule, 2 cc of culture medium is used. This amount is just sufficient to cover the tissue fragments, which are transferred to the flasks after the medium (see below) has been introduced and either remain suspended in the fluid or else loosely adherent to the glass. Finally, and in accordance with a routine procedure that has been followed in this laboratory for six years, the flasks are filled with a gas mixture[3] comprised of O_2, CO_2 and N. The gas mixture serves a double purpose: first, a certain amount of oxygen is required by the tissues as an aid to respiration; and second, a definite quantity of CO_2 is used to establish an appropriate hydrogen-ion concentration and to maintain it at a constant level. The composition of the gas mixture depends on the nature of the tissue, the composition of the medium and the purpose of the experiment. The moment the gas mixture has been introduced, the flasks are closed with rubber stoppers and sealed with waterproof cement[4] in the manner adopted several years ago for all cultures. The gaseous atmosphere is replenished daily.

At the termination of an experiment, and as a routine procedure, the tissue fragments are fixed, sectioned and stained for histological study. Just prior to fixation, the tissue from each individual culture flask is collected together in a flat, compact mass and embedded in a plasma coagulum on a piece of mica. This not only protects them from injury but also facilitates subsequent handling.

From time to time, comparative experiments have been made in which the same number of tissue fragments from the spleen of an adult rabbit were cultivated in equal amounts of plasma and serum prepared from the same sample of blood. Fragments placed in the solid plasma mixture showed less contraction than those cultivated in the fluid medium containing an equivalent amount of serum. Yet the state of preservation of the plasma cultures was only slightly better than those cultivated in serum. In fact, the differences were so slight that, for practical purposes they seemed almost negligible.

A comparative study was also made of the survival of sister cultures of rabbit spleen carried in an atmosphere containing 21 per cent., 40 per cent. and 80 per cent. O_2. In these experiments, the CO_2 content of the gas mixture was held uniform, whereas the N was varied with the O_2. The cultures were gassed for 3 minutes on the first day and for 1 minute on each day thereafter. The results obtained were most striking. Of the three concentrations of O_2, 80 per cent. gave by far the best cell preservation. After 4 days, cultures carried in 21 per cent. O_2 showed almost complete degeneration and necrosis in the central portion of the tissue fragments, whereas sister fragments cultivated in 80 per cent. O_2 showed almost complete survival. In 40 per cent. O_2, the survival was better than in 21 per cent. O_2, but still quite inferior to that obtained in the 80 per cent. mixture. It would seem therefore, that fluid cultures containing large quantities of organized tissue in suspension have very high oxygen requirements.

When 100 mg of rabbit spleen are cultivated in 2 cc of culture medium, special precautions have to be taken in order to prevent the medium from becoming too acid. This may be done by adding a slight excess of sodium bicarbonate. If, for example, the medium is made up to include 50 per cent. rabbit serum, 16 2/3 per cent. of an isotonic solution of sodium bicarbonate (1.4 per cent.), 33 1/3 per cent. Tyrode solution containing 4 times the usual amount of glucose and 0.01 per cent. phenol red (to serve as an indicator), it will be very alkaline in the beginning but may be adjusted immediately to pH 7.2 by the introduction of a gas mixture containing 8 per cent. CO_2. On the first day it is usually necessary to gas the cultures for a period of 3 minutes in order to attain this. Thereafter, the time may be greatly reduced. When, as occasionally happens, the medium becomes too acid and it is necessary both to remedy this and, at the same time, to treat the cultures with a gas mixture containing a higher concentration of O_2 than is contained in the atmosphere, the flasks are unstoppered and left for a time in the incubator with their openings protected with sterile gauze. As a result of this treatment, the medium will lose a certain amount of CO_2 and become more alkaline. It may then be brought back to the desired hydrogen-ion concentration by introducing a mixture containing 3 per cent. CO_2 and the desired amount of O_2.

This system of cultivation has already been used to great advantage in a study of the formation of antibodies *in vitro*.[5] It offers a simple means of keeping

projectoscope. Also, the dorsal surface of the flask is made with a certain convex curvature that facilitates projection.

[3] The gas mixtures are made up in high pressure storage tanks by means of Hoke valves and a 100 lb. pressure gauge, each gas being led in separately until the desired pressure (percentage) for that particular gas has been obtained. Separate tanks are made up to contain varying concentrations of O_2 and CO_2, the balance in each case consisting of N. Eventually, the gas mixture is fed into the cultures through a saturation flask (containing 1 per cent. copper sulphate), a 1-inch "N" Berkefeld filter (to render the mixture sterile) and a sterile glass pipette. The sterile filter is replaced daily. The glass pipettes are changed much more frequently, and just as often as there is doubt of their sterility.

[4] Du Pont's clear airplane dope No. 5332.

[5] K. Landsteiner and R. C. Parker, unpublished experiments.

adult tissues in a state of functional survival rather than one of unlimited proliferation. It also renders it possible to study simultaneously both the effect of the medium on the cells and the effect of the cells on the medium. Thus, for example, the entire medium may be changed without removing the suspended fragments, or any part of it may be withdrawn at any time in order to test it for the presence of particular substances elaborated by the tissues.

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PULSATING BLOOD VESSELS IN THE OYSTER[1]

DESCRIPTION was recently published[2] of a pair of "accessory hearts" in the oyster. These structures are large, well-defined, thin-walled blood vessels in the mantle wall of the cloacal chamber and apparently pump blood from the excretory organs into the pallial arteries, which run around the borders of the mantle lobes. They pulsate independently of one another and at a rate considerably slower than that of the heart.

Further studies on *Ostrea lurida* have demonstrated that these organs are only the two most prominent of a great many pulsating peripheral blood vessels in the walls of the mantle. These vessels may be seen on the inner surface of each mantle lobe as radially arranged structures extending from the region of the adductor muscle and visceral mass to the tentacle-bearing periphery. They are of greater diameter toward their distal ends than centrally and are sometimes branched. Examination of sections shows that these vessels are directly associated with and partially surround the bundles of muscle fibers which function as retractors of the mantle.

A well-defined band of tissue, the cilia on which beat posteriorly, runs in each mantle lobe from a point adjacent to the labial palps to the postero-ventral border of the lobe. Underneath the ciliated epithelium of each of these bands, throughout at least a large part of its length, is a blood vessel which also pulsates rhythmically. At its posterior extremity each band with its underlying blood vessel becomes continuous with one of the radial blood vessels near the edge of the mantle, while along its course it crosses the radial vessels and appears to be directly continuous with many or all of them.

All these vessels (the accessory hearts, radial vessels and the horizontal bands) apparently open directly into the circumpallial vessel at the border of the mantle. These vessels are hardly more than indefinite blood spaces with such poorly defined walls that it is difficult to trace their origin, save in the case of the accessory hearts which originate in the blood spaces of the excretory organs. The pulsations of the radial vessels progress toward their distal ends as very distinct, relatively slow constrictions. The wave of pulsation of the vessel underlying the ciliated band begins anteriorly and as it crosses the radial vessels appears to be synchronous with pulsations of the latter.

Observation of the activity of these vessels is most difficult. When the oyster is removed from its shell the mantle becomes curled back and distorted because of contraction of the bands of muscle fibers. The structures were best observed by removing only one valve, leaving one mantle lobe still in contact with its shell. Also, small oysters, or spat 10 to 15 mm long, caught on glass plates were observed by transmitted light, making it possible to see both the waves of contraction and, in some cases, the direction of movement of blood corpuscles.

All pulsations proceed toward the periphery of the mantle, and during the contraction the blood cells go in the same direction. There appears, however, to be no effective valve action to maintain flow of blood in one direction, for as the vessels expand again the blood corpuscles reverse their direction of movement, though going more slowly.

The function of these pulsating vessels is as yet not entirely clear, though it may be to move the blood back and forth through the mantle to facilitate aeration. It is possible that the radial vessels, like the accessory hearts, receive their supply of blood from the excretory organs, though this has not been demonstrated. In the case of *O. lurida* it is doubtful that the marginal vessels of the mantle have a direct connection with the arterial system, as in *O. gigas*.

Blood in the marginal vessels (the pallial arteries or sinuses) may be observed to flow alternately back and forth, depending upon pulsations of the radial vessel as well as upon a pulsating activity of its own. Blood is collected in veins near the outer surface of the mantle and returned to the auricles.

A study of the anatomy of these contractile vessels is being made in order to establish what structures produce the pulsations. It appears probable that cells of the type of "Rouget cells," as investigated by Federighi[3] in *Nereis*, may be the agents responsible for the observed activity.

A. E. HOPKINS

U. S. BUREAU OF FISHERIES

[1] Published by permission of the Commissioner of Fisheries.

[2] A. E. Hopkins, *The Biological Bulletin*, Vol. 67: 3, 345–355, December, 1934; SCIENCE, 80: 2079, 411–412, November 2, 1934.

[3] Henry Federighi, *Jour. Exp. Zool.*, 50: 2, 257–294, February 5, 1928.

THE COMPARATIVE EFFECT OF TWO IRON SALTS ON PARASITIC ANEMIAS IN PUERTO RICO[1]

A COMPARATIVE study has been carried out on the effect of iron ammonium citrate (ferric) and iron sulfate (ferrous) on the anemias associated with hookworm disease and with schistosomiasis mansoni.

The response to large daily doses per os of iron ammonium citrate (6 gms) in hookworm anemia has been reported by several investigators.[2,3,4] Rodríguez-Molina and Pons[5] have studied the effectiveness of this drug in the anemia associated with the intestinal phase of schistosomiasis mansoni. This condition is produced by a unisexual blood fluke living in the portal vessels of its most common host, man. It produces chronic dysentery, and later, fibrous and papillomatous growths in the lower intestinal tract, cirrhosis of the liver with splenomegaly and anemia.

In hookworm disease the administration of each of the therapeutic agents used (6 gms iron and ammonium citrate; 1 gram iron sulfate, daily) during a period of thirty days without removal of the worms resulted in a rise of the red cell count and hemoglobin percentage to a practically constant subnormal level accompanied by definite clinical improvement. After removal of the worms the blood values rapidly rose to normal levels (5 to 7 days).

In schistosomiasis mansoni, however, 2 gms of iron sulfate were required to produce improvement in the red cell count and hemoglobin percentage, compared to that obtained with the use of 6 grams of ammonium citrate.

From the above evidence, it is suggested that the administration of iron sulfate (in the solid form) is easier and less bothersome to the patient than the use of a solution of iron ammonium citrate. Gastrointestinal disturbances such as diffuse abdominal pain and diarrhea have been observed during the administration of both drugs, but are less frequent when iron sulfate is administered.

The difference in the quantity required of the two drugs employed in this study might possibly be explained in terms of degree of oxidation of the iron or a difference in its assimilability in the gastrointestinal tract.

R. RODRÍGUEZ-MOLINA
JUAN A. PONS

[1] From the Department of Medical Zoology and University Hospital of the School of Tropical Medicine of the University of Puerto Rico under the auspices of Columbia University.

[2] R. M. Suárez, *P. R. Jour. Pub. Health and Trop. Med.*, 8: 299, 1933.

[3] C. P. Rhoads, W. B. Castle, G. C. Payne and H. A. Lawson, *Medicine*, 1934, 13: 317, 1934.

[4] R. Rodríguez-Molina, *P. R. Jour. Pub. Health and Trop. Med.*, 11: 49, 1935.

[5] R. Rodríguez-Molina and Juan A. Pons: Unpublished observations.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

RAISING THE PRAYING MANTIS FOR EXPERIMENTAL PURPOSES

PHYSIOLOGISTS and psychologists have long sought an insect suitable for experimentation. Grasshoppers, bees and cockroaches have been the subjects of various investigations but have definite limitations, either being too small for satisfactory operative techniques or flying or jumping, making accurate observation difficult. A number of generations of the praying mantis have been raised in this laboratory over a period of four years, and this insect has proved ideal for experimental purposes. At the moment it is being used in an investigation of the functions of various ganglia and in studies on insect vision. It is therefore felt that a brief description of the insect and methods for raising it might be of interest to those seeking material for psychophysiological experiments.

The species used is *Mantis religiosa*—a species accidentally introduced into this country from southern Europe. The adult female is four to five inches in length, the male being somewhat smaller and slimmer. Both sexes possess wings, but these are rarely used. In general mantids move but little unless hungry or disturbed, though they are able to run at a considerable speed. They are positively phototropic though not markedly so, and are negatively geotropic, usually hanging upside down from the top of a container. They are entirely carnivorous, the food consisting of living insects which are captured with the modified first pair of legs and torn to pieces by the powerful mandibles. Unfortunately, the adults are cannibalistic, and must be kept in separate containers. Almost alone among insects the mantis is able to move the head in any direction. The eyes are large and vision relatively acute, and three different types of response to moving objects have been detected. Also there are a number of complex cleaning and copulatory reflexes in addition to simpler segmental avoiding reflexes, all of which make the mantis valuable material for observation and experimentation on insect behavior. Further details can not be given here, and reference should be made to papers by Binet[1] and Roeder.[2]

Mantis religiosa belongs to the order Orthoptera, and anatomically the nervous system is of a generalized insect type. The ventral ganglia are widely separated

[1] L. Binet, "La Vie de la Manté religieuse," Vigot Freres, Paris, 1931.

[2] K. D. Roeder, *Biol. Bull.*, 69, p. 203, 1935.

and the paired connectives are separate. The supra-esophageal ganglia are small, with the exception of the huge optic ganglia. The simple gross structure of the nervous system simplifies operatic procedures, though unfortunately there is very little information on its histological structure.

The method of raising practiced here is somewhat similar to that mentioned by Przibram[3] who worked with *Sphodromantis bioculata,* a different species. The egg cases, containing 150 to 200 eggs, can be obtained during the winter months for a small sum from any of the larger supply houses. They should be suspended by a thread in a 16-ounce wide-mouthed bottle, which is closed with a piece of bolting cloth secured by a rubber band. A hole about half an inch in diameter should be cut in the cloth and plugged with cotton. This is to allow for the introduction of food. The eggs should be kept at a temperature of 25° to 30° C., and a 50 to 70 per cent. humidity, and should be inspected daily. Under these conditions the eggs usually hatch in three weeks. Previous to hatching a large continuous supply of wild type Drosophila should be on hand. In this laboratory the Drosophila are raised in quart bottles in the same incubator with the mantids. At least one quart bottle of Drosophila culture for every five mantids should be allowed. It is important to have a constant supply of flies, as the young mantids hatch with no food reserves and quickly starve. They usually refuse food for the first 12 to 24 hours after hatching, and a number will die. During this first day the most viable of the young nymphs should be selected and transferred with a camel's-hair brush into a 16-ounce bottle covered with cloth, as mentioned above. A little sand and a few twigs should be placed in the bottles to give the insects a foothold and prevent them crowding in one part of the bottle. Not more than 10 to 15 nymphs should be placed in one bottle. The bottles containing the mantids are then placed in an incubator at 25° to 30° C., which should be illuminated artificially or by daylight. This is important, since mantids catch their prey entirely by sight and the acuity of vision is greater in higher light intensities. They should also be lightly sprayed with water from an atomizer once a day, though too much water may drown them in the first instar. During the first day a number of living adult Drosophila should be introduced. This is simply done by holding an eight-ounce wide-mouthed bottle over the quart bottle containing the Drosophila culture. When the flies have passed into it, it is removed and held over the hole in the jar containing the mantids. If it is tapped lightly the flies will fall through the hole in the cloth, and the cotton stopper can be replaced. The flies will soon be captured and eaten, only the wings and harder portions being discarded.

After a week to ten days the mantids will moult for the first time, and care should be taken to disturb them as little as possible at this time. Since they do not eat for a day before and a day after moulting the food can also be reduced during this period. It takes nine to ten weeks at 25° to 30° C. for them to reach full size and sexual maturity, and during this period they will moult seven times. Drosophila or aphids make ideal food for mantids during the first three instars, but as they increase in size they require larger food. Any insect which is not strongly negative to light is suitable, and flies of all kinds, grasshoppers, moths, caterpillars and cockroaches have all been employed. Insects larger than the mantids will not usually be attacked and should not be presented. During the winter months living insects are more difficult to obtain, but meal worm larvae, cockroaches and flour moths can usually be obtained from neighboring factories and warehouses. On several occasions, when the food supply has failed, the mantids have been kept alive by feeding them by hand with meal worm larvae or even small pieces of frog liver. The food is held to the mouth of the mantis so that the juice touches the maxillae; it will then be grabbed and eaten. This is obviously a laborious process, and should only be resorted to when nothing else can be obtained.

As already mentioned, the mantids are cannibalistic, but this trait is not common until they become half grown, unless they are underfed or overcrowded. By the fifth instar they should be further segregated until there are only one or two mantids to a container. The adults should be kept singly in battery jars or other suitable container and should be provided with twigs to serve as a foothold.

In the writer's experience the raising of *Mantis religiosa* in captivity presents little difficulty, the presence of an observer and other artificial conditions interfering with their normal habits, mating, etc., to an inappreciable extent. The only difficulties likely to be encountered are in the provision of a continuous supply of living food. Though this can be easily overcome during the summer months, careful planning of food supplies during the winter will result in a good percentage of perfect mature insects at any time of year.

K. D. ROEDER

TUFTS COLLEGE

[3] H. Przibram, *Blätter für Aquarien und Terrarienkunde,* 42, 669, 1909.

DECALCIFICATION AS A METHOD OF PREPARATION OF GROSS ANATOMICAL MATERIAL

IN an elective course in fetal anatomy, which follows the regular dissection course, the fetuses were dissected for some years using the method described by Scam-

mon.[1] Several years ago the study of cross sections was substituted. This later method seemed to give the student a new approach and a new idea of relations, which was beneficial not only in this course, but it also served as a review of the relations studied in the first course in anatomy.

Following the suggestion of Jackson,[2] fetuses were decalcified in 5 per cent. hydrochloric acid and then cut into rather thin sections of a centimeter or less in certain regions, with a long butcher knife. The hydrochloric acid was found to work satisfactorily for both the fetuses and for entire adult heads and then nitric acid of the same strength was tried. Nitric acid gave fully as satisfactory results, with even better differentiation of the tissues. In some cases there was a slight stickiness in the sections of both the heads and the fetuses decalcified with the nitric acid, which was not readily washed off. We found that we could use from 5 to 10 per cent. hydrochloric or nitric acid, changing the solution every week or ten days until a needle would easily penetrate the jaw bone, and then section with the knife.

Following the satisfactory results obtained with the adult heads and the fetal material, these methods were tried on other parts of adult cadavers. Material taken from a 2 per cent. phenol solution, used to store our cadavers, and put into nitric acid did not work satisfactorily. In many cases the tissues softened before the bone decalcified. Later on the material was put in a 10 per cent. solution of formalin for some weeks and then into a 10 per cent. solution of hydrochloric acid, following which excellent sections were obtained. They could be cut as thin as desired and the tissues were in excellent condition. From 5 to 10 per cent. solutions of hydrochloric acid seem to work equally well. The time varies, due to the character of the bone and the variation in the strength of the commercial acid used. The acid should be renewed every week or ten days for a period of from three to six weeks. The progress of the decalcification can be tested with a needle. When the needle passes into the jaw bone, temporal bone or other hard bone, the material should be removed, washed in water and cut.

This method of decalcification with hydrochloric acid has been found excellent for temporal bones, making the dissection of the human internal ear as easily done as that of the dogfish.

At first there was some trouble in holding the body of the fetus so as to get sections cut perpendicular to the axis of the body and parallel to each other. Recently we have been using a device similar to a carpenter's miter box. This is made very easily by nailing three boards together forming a trough just wide enough and deep enough to hold the fetus. A slit or guide is cut perpendicularly with a saw in the sides of the box toward one end and through this the long knife slides. The fetal cadaver is held securely by hand and advanced just the desired distance, the equivalent of the desired thickness of the sections. Lines may be marked on the cadaver for cutting as suggested by Ruth[3] after the decalcification and before the sections are cut.

Fetuses and adult entire heads may be decalcified in either weak hydrochloric or nitric acids, but adult material containing a larger proportion of soft parts is better decalcified in hydrochloric acid, with a previous soaking in strong formalin solution. Sections thus prepared are tough, not easily injured and may be cut as thin as desired. The edges are smooth, thus giving excellent differentiation of the various tissues. Sections fully as good as those from frozen material may thus be obtained when an expensive high speed band saw is not available. Decalcification of temporal bones or other head bones in hydrochloric acid makes the bone soft enough to permit its being cut away with a sharp scalpel.

HOMER B. LATIMER
UNIVERSITY OF KANSAS

[1] R. E. Scammon, *Anat. Rec.*, 21: 19–24, 1921.
[2] C. M. Jackson, *Jour. Am. Med. Assoc.*, 39: 813–817, 1902.
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